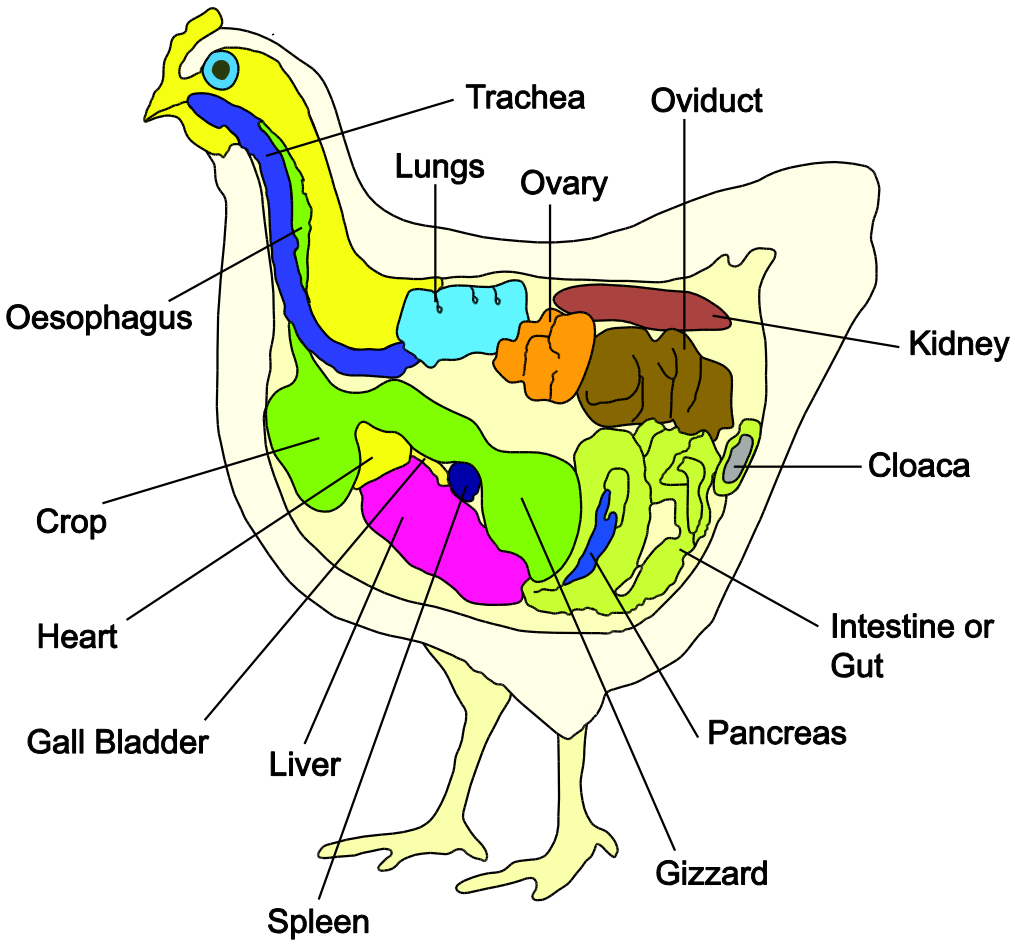
SOUTH AFRICAN POULTRY ASSOCIATION
SUID AFRIKAANSE PLUIMVEEVERENIGING

Learning Module 2

Anatomy and Physiology of the chicken



Contents

Anatomy and physiology of the chicken

Anatomy and Physiology of the Chicken

Note to the learner
The word anatomy means structure of the body and the organs in the body of the chicken. Physiology has more to do with the functioning of organs of the body, for example the digestion of and absorption of feed. This knowledge is essential not only to enjoy your work more but also to empower you to be in a better position to identify problems and to provide conditions for good production results.

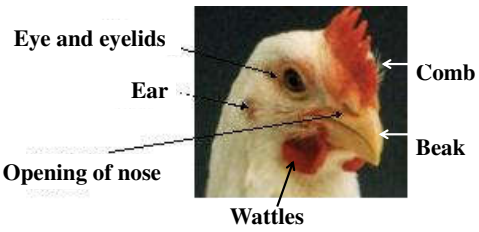
The external body parts

The external organs include the skin, eyes, ears, nostrils, comb and wattles and will be discussed first before proceeding to internal organs such as the digestive tract, reproductive system etc.

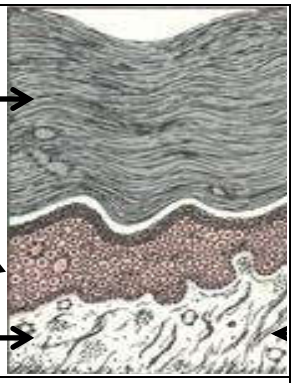
Cells are the real working units of the body and all tissue consist of cells:

Cells of muscle tissue are able to contract (shorten itself) to cause movement of the legs, wings etc. Liver cells make (produce) substances for the egg yolk. Cells lining the mouth cavity secrete saliva (moisture) to enable the bird to swallow feed. Skin cells consist of several layers of which the outer layer is tough and dry and protects the body. The cells in bone are filled with calcium and phosphorus to make bones strong to carry the weight of the bird.

Important knowledge:
The tissue of all organs consists of cells that enable that organ to perform its function. In young chickens growth is the duplication of cells of the various organs. Cells receive nutrients from feed by means of the blood stream for their duplication. The chemical reactions taking place inside cells result in heat being produced. This is the origin of the warmth of a living animal.

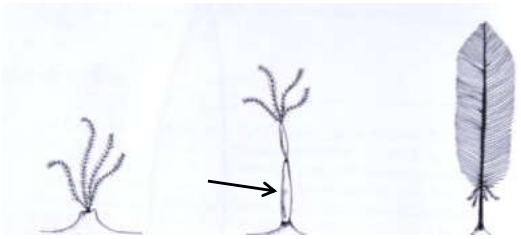
Poultry have good eye-sight: detect colour; prefer green and yellow. Shiny objects such as water droplets on a nipple line attract attention of young chickens.	
Can smell and will detect offensive smells. Will try to avoid areas where ammonia is in the air e.g. wet spots under drinker lines.	
Can hear very well. Noises such as banging of trolleys or crates and people shouting, cause stress and affect immune development after vaccination.	
The comb and wattles are well supplied with blood vessels. Cool air moving over these areas removes body heat. These organs thus assist with body temperature regulation in hot weather.	

The skin: Two functions, protection and regulation of body temperature



Protective function:
The outer horny layer has no blood supply, scratches through this layer will not result in infection but into the deeper layers infections will occur. Feathers growing from the skin have an insulating effect and protect the bird from losing heat to the environment during cold conditions.

The day-old chicken hatches with a fluffy hair-like structure called down. It has very little insulating value and the chick will lose body heat at temperatures of 25 °C.
The down is replaced with feathers formed by cells in the skin follicles. Feathers are replaced several times before adult feathers have formed.

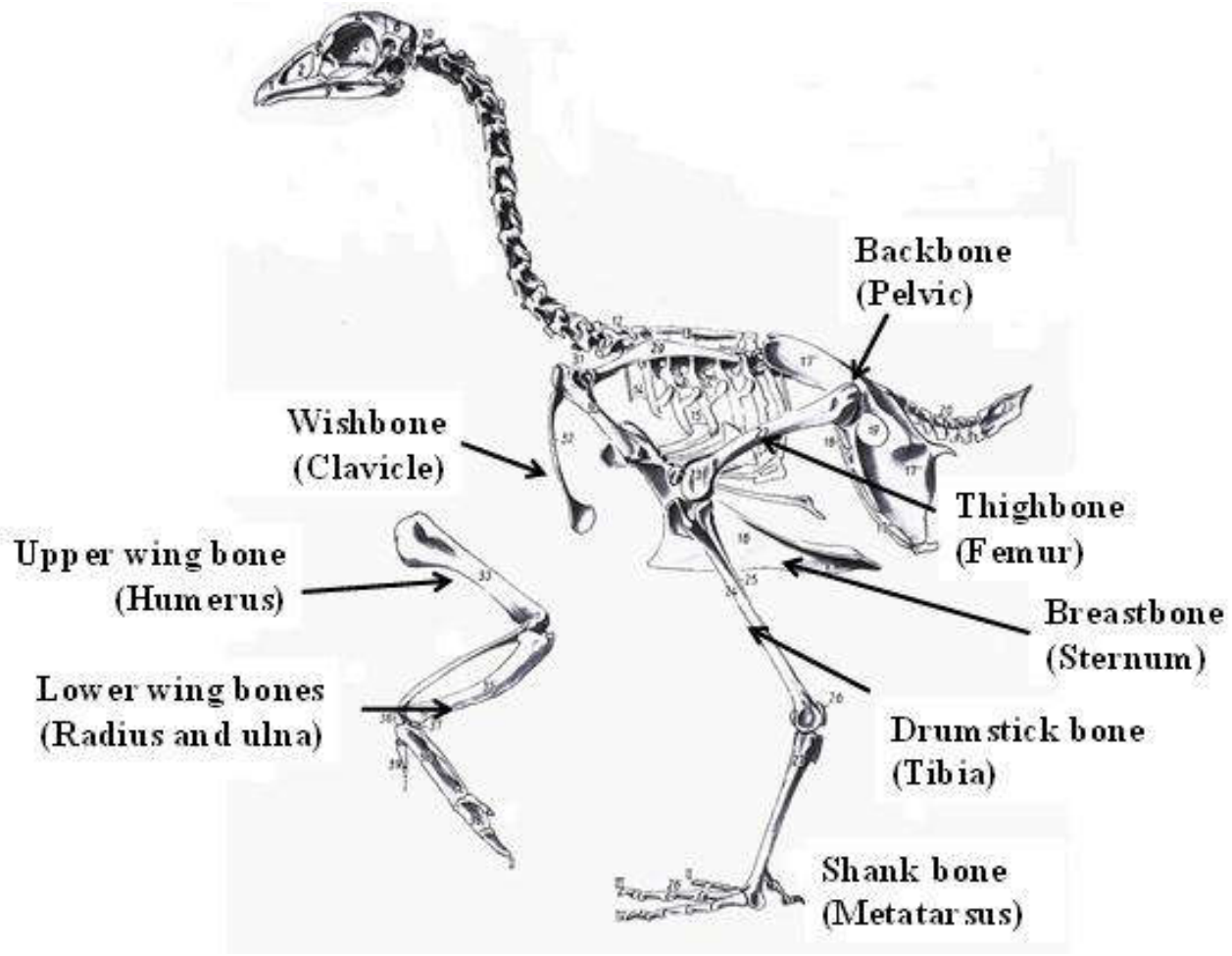


Left: Down in day-old chicken.
Centre: Arrow showing growth of feather follicle pushing down out.
Right: Mature feather.

The function of the skin is to protect the bird from losing moisture to the environment and also in the regulation of body temperature. Poultry do not have sweat glands like humans or horses or cattle. During very hot weather they pant with beaks open to lose moisture from the mouth where cooling then takes place.
Regulation of body temperature: The skin is very well supplied by blood vessels, and that causes the skin to be warm.
Cool air moving over the hot skin would thus cause cooling of the skin and cooling of the blood that flows back to the inner organs.
It is often seen on hot days that the chickens would raise their wings to allow air movement over the skin.
Important to realise cooling can only take place if the air temperature is cooler than body temperature of the bird.

Figure 1 Blood vessels to and from the skin

The skeleton of the bird

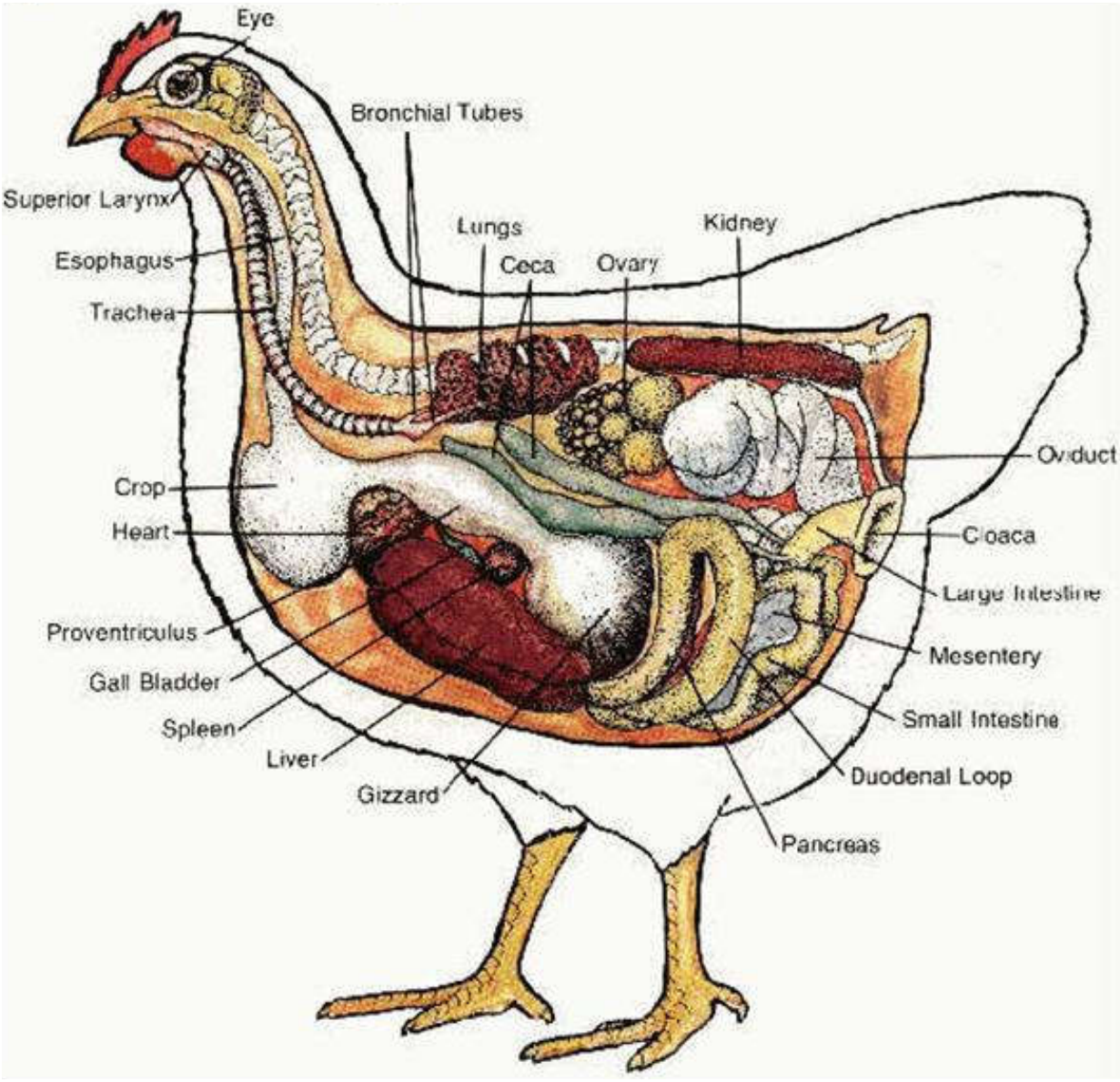


Skeleton of an adult chicken

Important knowledge:
Bone cells consist mainly of the minerals calcium and phosphorus.
The skeleton is a framework of bones to which muscles are attached.
The skeleton provides rigidity (firmness) to the body.
The skeleton provides protection to internal organs, for example the digestive tract, heart, lungs, kidneys and the reproductive system, etc.
Contraction of muscles results in movement of those bones to which the muscles are attached. All kinds of movement are brought about by such contractions: walking, flapping of wings, movement of the neck and head to pick up feed or to drink.
Also respiration where the body cavity is contracted or enlarged to expel air or to inhale air.

The internal organs of the chicken

Look carefully at the position of the organs inside a hen as shown in the illustration depicted below. In this section we shall be studying the functions of the internal organs. This will not only be a very interesting exercise to know what happens to feed and water after it has been consumed, but you will also enjoy to know more about the internal processes that take place in organs such as the lungs, the reproductive system and how body temperature is regulated. You will also learn more about those organs that are involved in protecting the chicken against diseases, the immune system.



Cross-section through the body of a hen.

The digestive tract[1]:

A critical link from feed to growth

The digestive tract has a most important role to digest feed and make nutrients available for utilization by cells to form and maintain all the different organs of the body. Important terminology like digestion, absorption, transport of nutrients and heat production will also be explained. Before addressing these aspects, please have a look at what are the basic components of a chicken's body, in other words what must the diet supply to enable the chicken to grow, see the table below which lists the composition of a chicken's body.

Composition of a chicken's body			
	The basic (main) components of the chicken's body are the following:		
	Water.	In a 100g chicken it amounts to	65g
	Fat.	In a 100g chicken it amounts to	15g
	Minerals.	In 100 g chicken, (mainly calcium and phosphorus) amounts to	4g
	Proteins.	In a 100g of chicken it amounts to	16g
Conclusion	When looking at a chicken, everything you see, whether from outside or in an opened bird, if the substance is not fat, minerals (as in bone tissue) or water (in blood or as wet tissue), then it is protein. Not only is dry, fat-free muscle pure protein, but also the feathers, toe-nails, dry fat-free liver, intestine, skin and many other dry, fat-free soft tissue.		

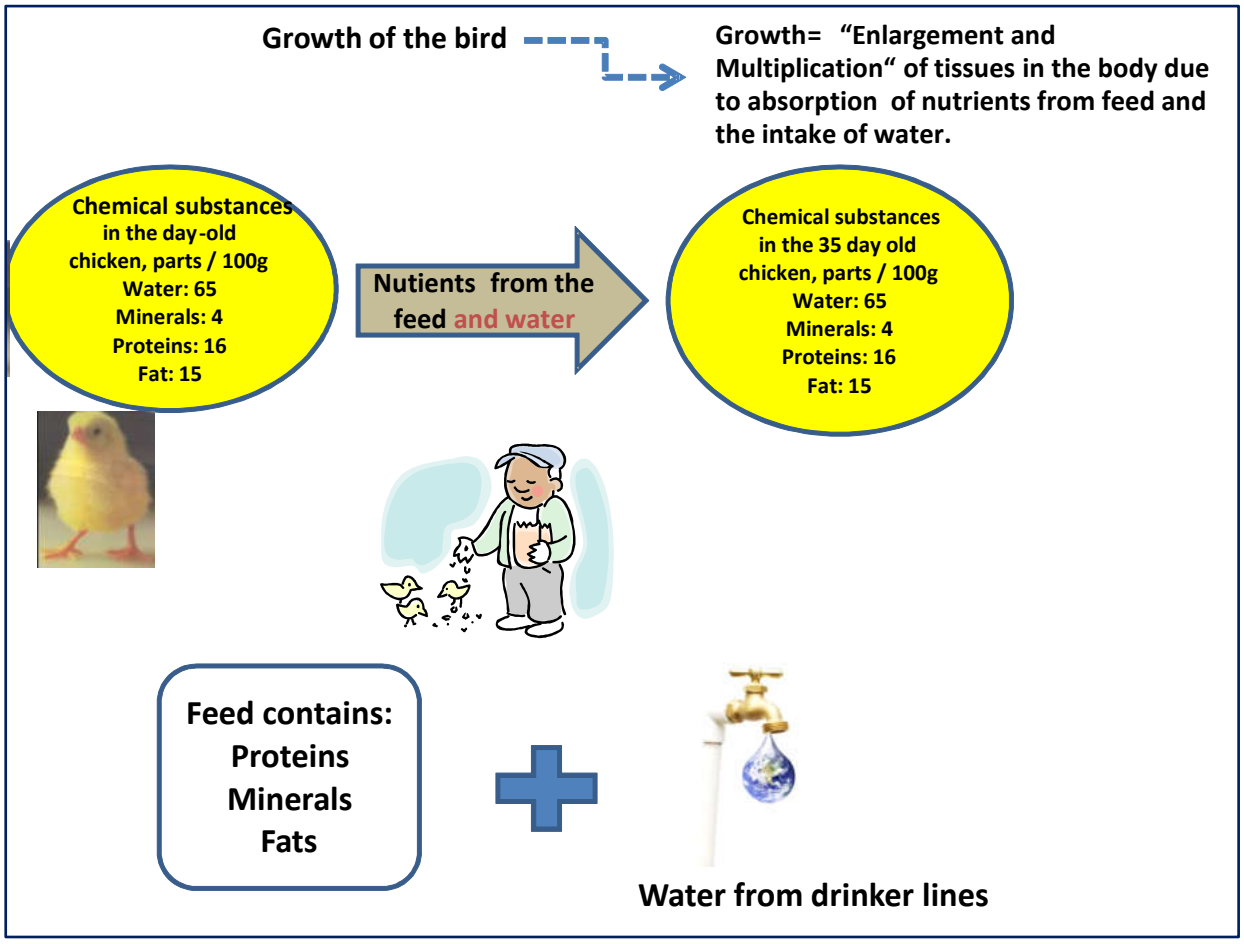
The main functions of the components mentioned in the above table are summarized in the following table functions of the different components in the body of a chicken.

Functions of the different components in the body of a chicken	
Important and useful knowledge 	**Water:** All the many reactions inside body cells can only take place in water,
	Fat: It is a source of stored energy for the chicken.
	Minerals: Such as calcium and phosphorus are the main components in bone cells and make bones strong and rigid.
	Proteins: Are the chemical compounds of meat, feathers, toe-nails, the comb, wattles, intestines, the respiratory tract, etc. Everything that's not fat, water or minerals. Proteins in feedstuffs must first be digested to absorbable components, called amino acids. Amino acids are then used by the cells of an organ to form muscle cells, skin cells, liver cells etc. to enlarge, grow, organs.
	All processes where an action is performed, for example growth, movement, heart contraction etc require energy. This energy is obtained from glucose.

[1] **Another term is the gastro-intestinal tract**

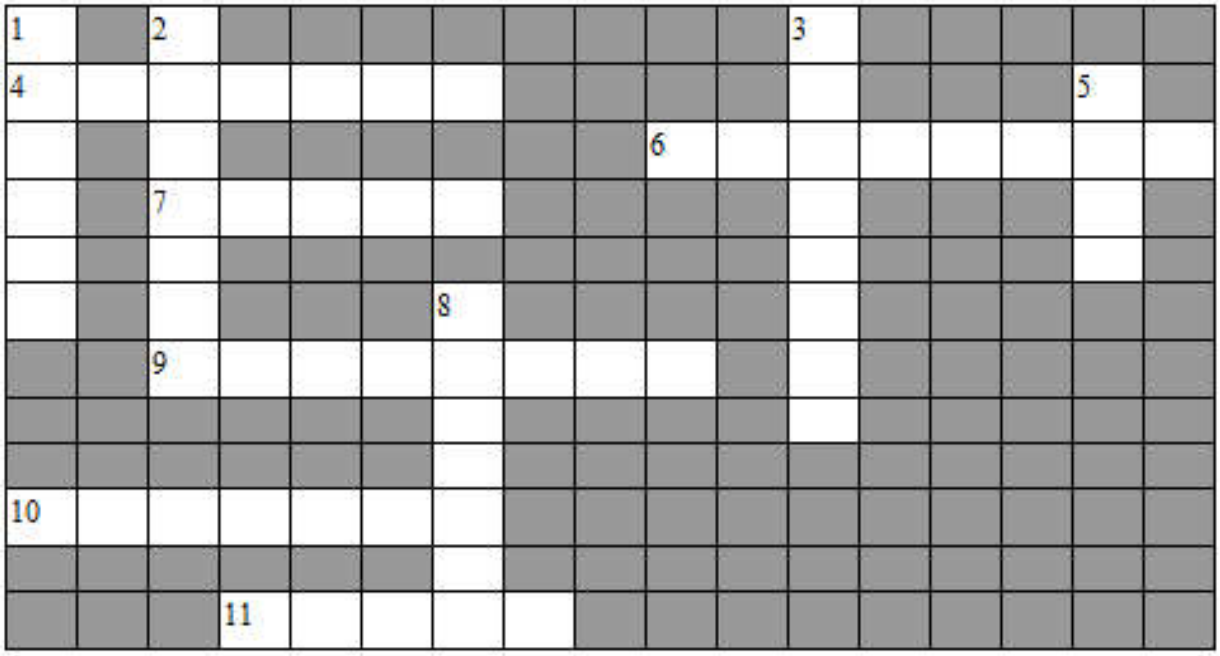
Summary of the feed and growth process. In all body cells of the bird, energy from glucose, is constantly being used to drive reactions that keep the body cells alive.
Look carefully at **Error! Reference source not found.**Write down what you regard as growth and the consituents necessary for growth of a chicken. You will see that the basic components and their ratios are basically the same in a day-old chicken and the broiler at 35 days.

NUTRIENTS FROM FEED + WATER = GROWTH OF THE BODY



Summary of growth processes

Test you knowledge memory challenge number 1



Clues Across	Clues Down	
	1	Fluid secreted by cells in the mouth of the chicken
	2	One of the main minerals in bone cells
	3	The type of reactions responsible for the warmth generated in the body
	5	The feather-like structures with which the day-old chicken hatches
	8	One of the four components of the body that is not water, minerals or fat
4		Word describing the structure of the body
6		The framework protecting inner organs of the bird
7		The working units in tissue of organs
9		One of the four components of the body that is not protein, water or fat
10		This substance serves as the source of energy for a chicken
11		These acids are the building blocks of proteins

Note to the learner.
Memory challenge number 1 is based on information you have learned so far on poultry Anatomy and physiology. See how far you can get without referring to the notes. If you find that you are not able to complete the challenge a suggestion is to read through the notes again slowly and carefully. Should you find that you are unable to understand some of the concepts then you need to discuss these with your supervisor or facilitator.

The functions of the different parts of the digestive system.

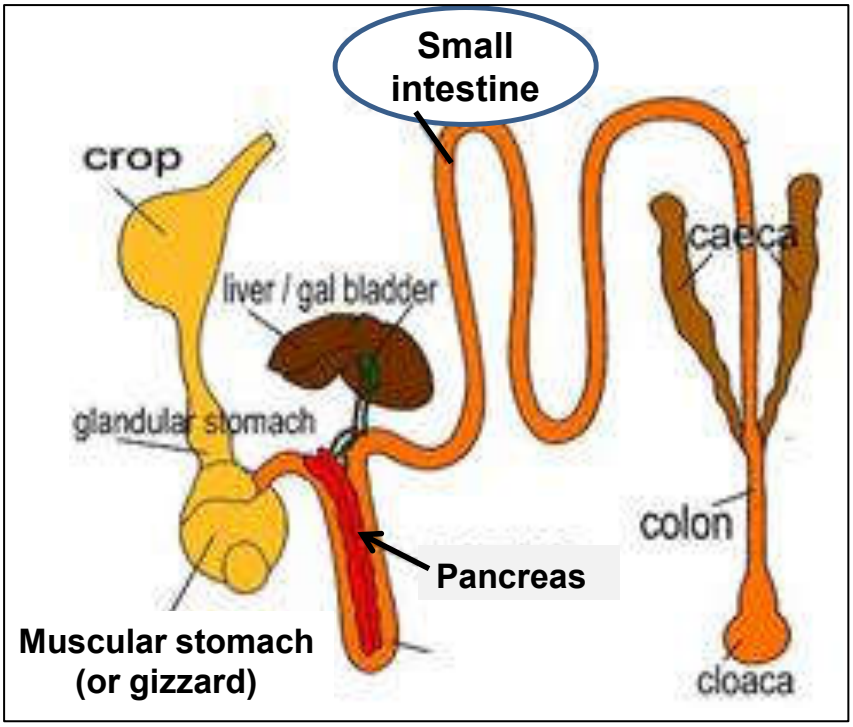
Mouth and crop

Important knowledge  **Refreshing your mind**	Digestion is the process of making feed available for absorption into the body: • Proteins in feed are digested to amino acids. • Starch in feed is digested to glucose. • Fat is digested to fatty acids. • (Water and minerals are not digested but absorbed as such)

The feed is picked up and swallowed by means of the tongue. Salivary glands[2] in the mouth secrete mucus (*slym*) to enable passage of feed down the tract. (***Read the footnotes indicated by subscripts.***)

The chicken has taste buds on the tongue and can distinguish between different flavours. It prefers sweet but will reject a bitter taste. Although taste does not play a very important role in the control of feed intake by birds, they will reject feed that has become rancid[3] or feed containing high levels of salt.

The crop serves as storage organ and no digestion takes place there. However, it is in the crop where feed is mixed with water to soften feed particles to enable the penetration of acid[4] which improves the digestion process, availability of water is most important.



[2] A gland consists of cells capable of producing and secreting products such as mucus (saliva, spit) in the mouth.

[3] Rancid means the fat has developed a bad smell during storage

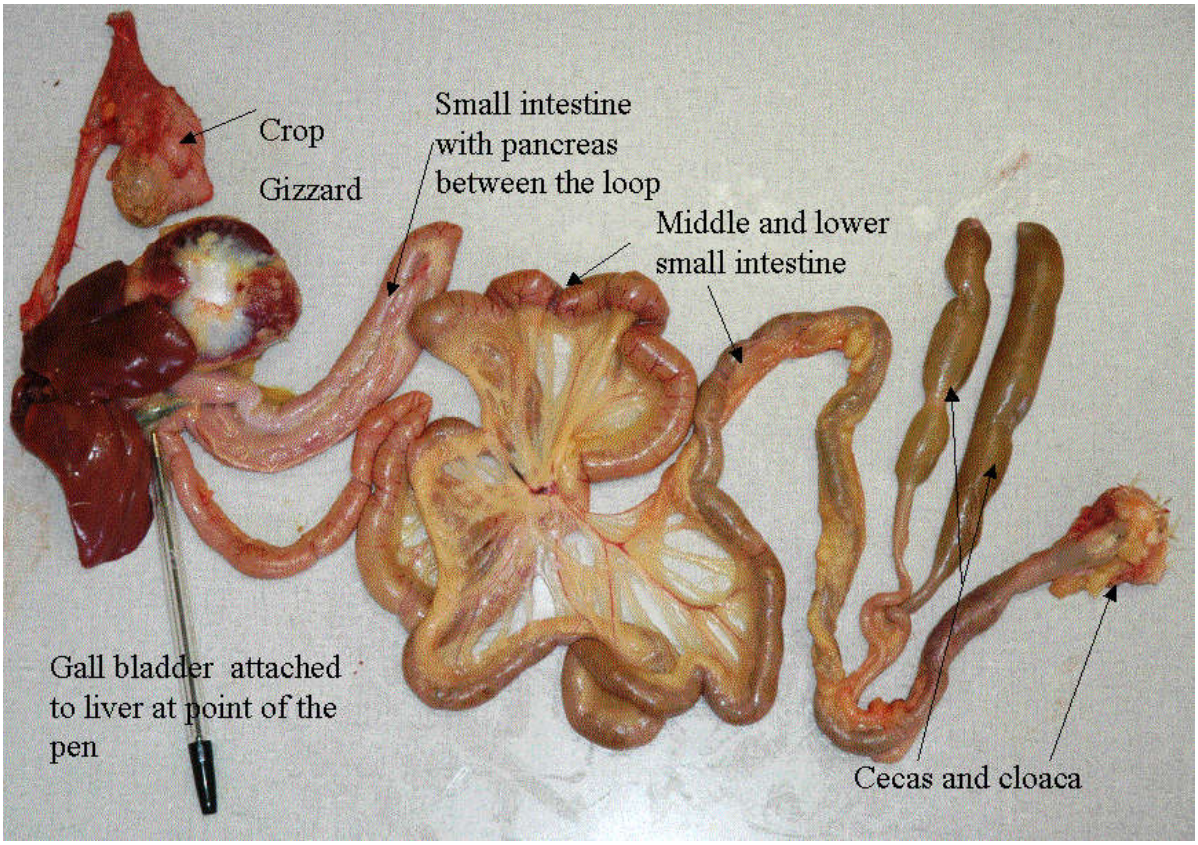
[4] Hydrochloric acid. (*soutsuur*) This is the acid also used in the water purification plant to adjust the pH of the drinking water.

Glandular stomach (or proventriculus)

This is the first section of the gastrointestinal tract, see the diagram called the digestive tract of the chicken, where digestion really begins. (Digestion means *breaking up* into small absorbable portions). The cells lining the glandular stomach secrete enzymes that digest proteins to amino acids.

Muscular stomach (or gizzard)

The gizzard with its strong muscles and tough inner lining is very effective to grind tough particles into a pulp on which enzymes can react very efficiently during the digestive process.



The digestive tract of the chicken

Small intestine and enzyme actions

In the small intestine most by the wall of the small intestine into the blood stream and carried to the different body parts where they fulfil their functions: amino acids to be formed into proteins glucose and fats to be used as energy sources of the digestive reactions and the absorption of nutrients take place. The inner wall has finger-like structures that secrete (produce) a variety of enzymes that react with feed proteins, starch and fats to digest these components into their smallest units. Proteins to amino acids, starch to glucose and fats to fatty acids. These are absorbed by the wall of the small intestine into the blood stream and carried to the different body parts where they fulfil their functions: ammino acids to be formed into proteins, glucose and fats to be used as energy sources.

The pancreas.

Keep in mind that the pancreas, the organ that lies in the loop of the small intestine, also plays a most important role in the production and secretion enzymes. These enzymes flow via a tube into the small intestine where they also act on starch, proteins and fats in the feed to enable the bird to digest feed very efficiently. The only substance that cannot be digested is the fibre layer surrounding a mealie or wheat kernel.

Household items: starch, glucose, protein and enzymes

Maize meal and maize starch are very common items in most kitchens, maize starch[5] or "Maizena" is a firming agent in gravy. In the intestinal tract of the chicken starch has to be broken down by enzymes to glucose before it can be absorbed and used as energy source by the tissue cells. Glucose is indeed also a very common item used in sports drinks such as *Game*.

Protein in the household.

Gelatine is a pure protein and dissolves in hot water. It is used for making jelly or puddings. It occurs with other proteins in tendons[6], that tough, white tissue at the end of a muscle and is normally the attachment to the bone.

Enzymes can be bought in pure form. On a bottle of meat tenderiser you will note in the list of ingredients it contains salt, a number of other substances, and *proteolytic enzymes*[7]. The client is advised to allow 30 minutes after the meat tenderiser has been rubbed into the meat before cooking or roasting the meat.

The toughness in meat is caused by tendons. They are those white threadlike structures in the muscle that are connected to the bone, in other words they are part of the muscle. The chemical reaction between the enzymes and those proteins of the tendon takes time to be broken down, thus the reason for time to allowed for the reaction to take place.

Gall bladder (*galblaas*)

This sac-like organ is attached to the liver and can easily be recognised by it bluish-green colour. Gall is produced by the liver and the function is to break up fats and oil into very small droplets that mixes with water. The reaction between enzymes and the fat can then take place to break it down into fatty acids

Caeca and colon

The lower portion of the intestinal tract consists of the two caeca's, and the colon, No absorption of

[5] Starch is also the major component in products such as rice, potatoes, wheat and oats and there are indeed also many industrial uses for starch in foodstuffs and in glues.

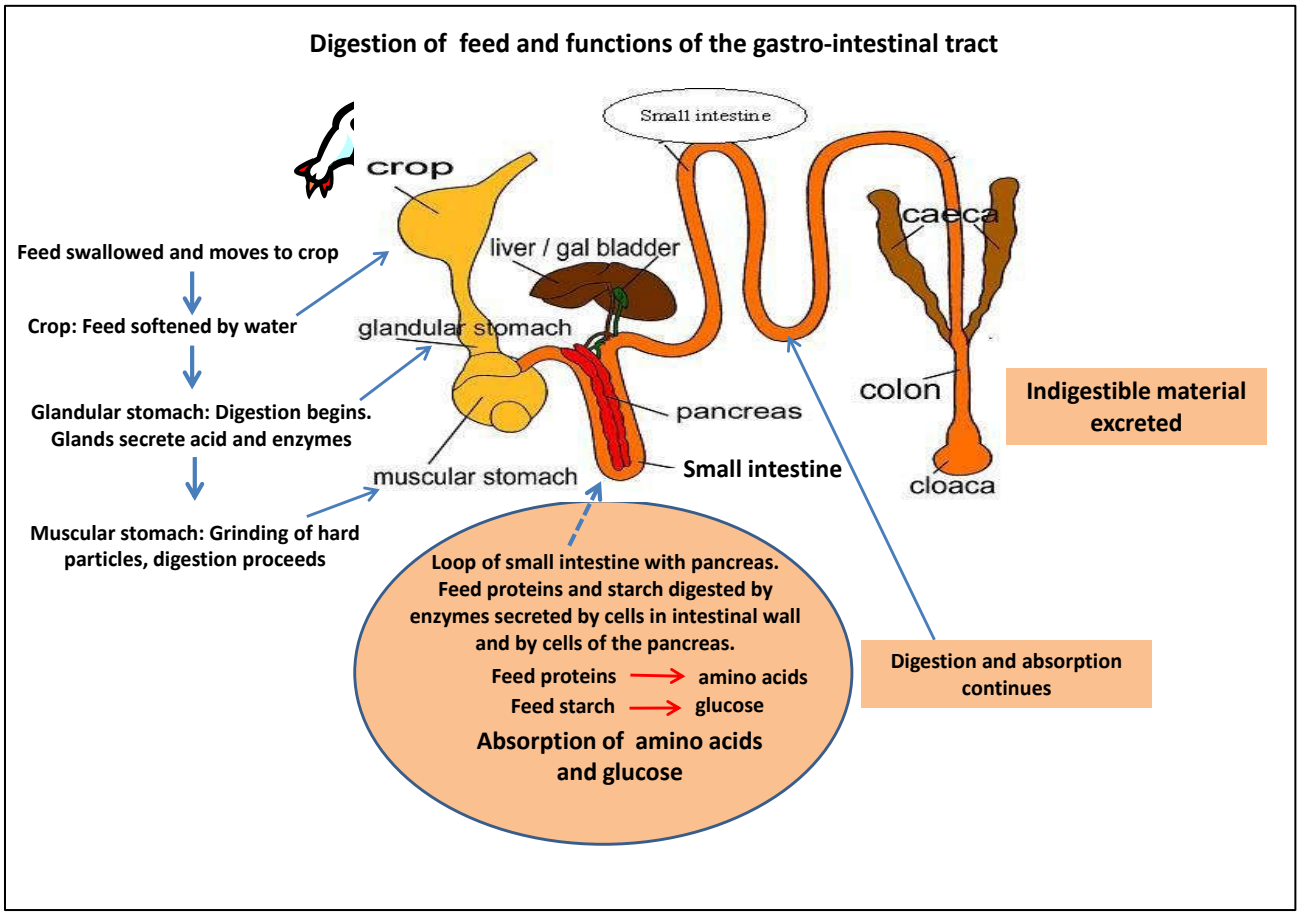
[6] Tendons are described as connective tissue and consist of collagens, the collective name for a number of proteins in connective tissue. One of these proteins is gelatin and is extracted by an industrial process of filtration.

[7] Proteolytic enzymes: chemicals that are able to digest proteins, break them up into their smallest building blocks

nutrients takes place here. Only water can be absorbed in the very lowest part of the colon, close to the cloaca, and this saves the amount of water that a bird has to drink to transport indigestible material through the gastro-intestinal tract.

The cloaca

The cloaca, also known as the vent, serves as a temporary storage organ of the indigestible feed residues and uric acid. In adult males the sperm ducts (tubes), or in females the tube (oviduct) in which the egg is formed, also have their openings in the cloaca.



Summary of events after feed intake by the bird.

Test you knowledge memory challenge number 2

Clues Across	Clues Down	
	1	This is the source of energy used by cells and is the result of the digestion of starch
	2	The acid secreted by the wall of the glandular stomach that assists with the digestive process
3		Glands that secrete saliva
4		In that part of the digestive system feed is softened by water
5		Acids resulting from the digestion of proteins
6		The organ in the loop of the small intestine that produces enzymes for the digestion of proteins, fats and starch.
7		This material cannot be digested by enzymes and excreted in the faeces
8		Produced by the liver to break fats up into small droplets to for enzymes to react with the fat.
9		The organ that grinds feed to increase surface areas on which enzymes can act to digest proteins, starch and fats in feed.
10		The last part of the gastro-intestinal tract where water that was contained in faecal matter, is absorbed.

Note to the learner.
Memory challenge number 2 is based on information you have learned since completing the last memory challenge. See how far you can get without referring to the notes. If you find that you are not able to complete the challenge a suggestion is to read through the notes again slowly and carefully. Should you find that you are unable to understand some of the concepts then you need to discuss these with your supervisor or facilitator.

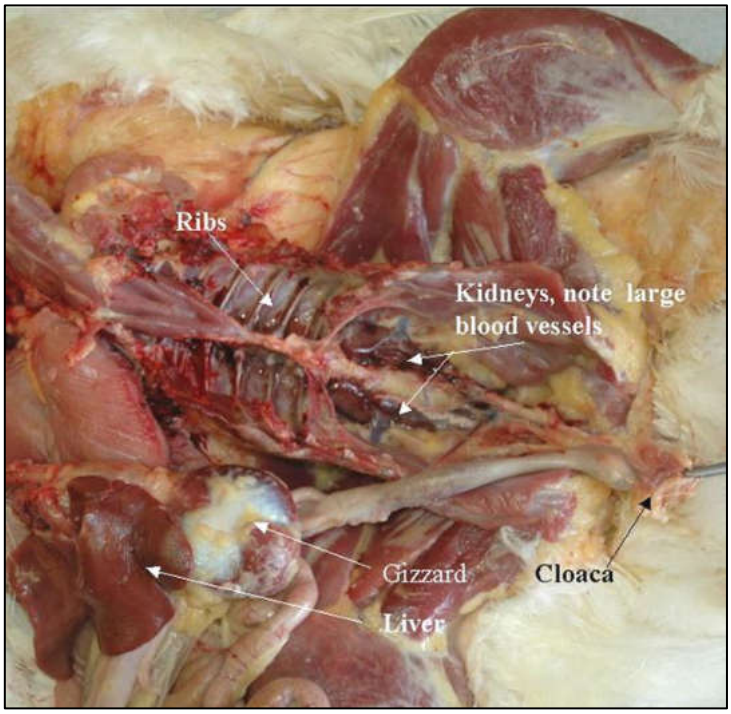
The urinary system of the chicken: the kidneys.

In poultry the white topping on the faeces is the chicken's *urine*. It consists of uric acid, a totally insoluble substance in water and is stored as a paste in the cloaca and excreted with the faeces.

Important knowledge. 	Uric acid is the waste product from chemical reactions inside body cells and is passed into the blood stream. Function of the kidneys is to remove uric acid from the blood by means of filtration

The kidneys, see picture on the right, have the ability to separate uric acid particles from the blood by means of a filtration process into the urinary tubes that run to the cloaca.

During serious dehydration[8] (read the footnote) uric acid crystals will block the tubes in the kidneys as well as those running from the kidneys to the cloaca. Access to drinking water for chickens is of utmost importance.



The white uric acid crystals on the livers and kidneys of day-old chickens that suffered from dehydration, can be identified during a post mortem.

Feed containing exceptionally high levels of salt due to mixing errors, will result in birds consuming large quantities of water. Salt is soluble in water (unlike uric acid!) and the kidneys excrete the salt as a watery solution. (One should not be mistaken to see the situation as diarrhoea because of the watery appearance of the excreta.) In poultry houses with wet bedding material, bacteria acts on uric acid and convert it to ammonia gas. Under dry conditions these reactions by the bacteria cannot take place.

[8]Dehydration is when the bird has lost water from the body cells. This can happen during excessive panting in hot weather or accidental water restriction for prolonged periods of time.

Respiratory system: lungs and air sacs

Important knowledge. 	Chemical reactions in body cells use oxygen[9] to obtain energy from glucose[10] and carbon dioxide is produced during this combustion process. Oxygen is carried by the blood to body cells and exchanged for carbon dioxide. In the lungs the carbon dioxide is given off to the inhaled air in exchange for oxygen.

The extraction of oxygen from inhaled air is very efficient in poultry. The lungs are connected to a number of air sacs in the body cavity, which enables the bird to extract oxygen twice from inhaled air, during inhalation and again when air leaves the body, in other words during exhalation.

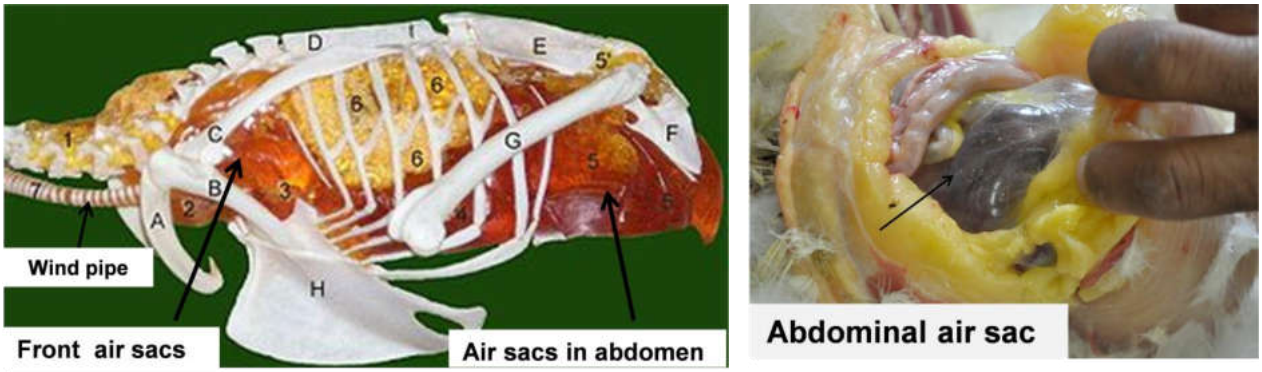


Diagram of the position of air sacs in the body. Right: Inflated air sac in abdominal cavity.

During this combustion process of glucose, heat is generated and these reactions are the source of heat that enables the body to maintain a temperature of 42 °C. The fact that heat production is an on-going process (as long as the bird is alive), heat has to be given off constantly to air surrounding the bird; this is to prevent the temperature of the bird from increasing. An important aspect with regard to the fact that poultry breathes air into air sacs of the body cavity, is the danger of inhaling bacteria such as *E. coli* that can cause an infection in areas close to the intestines, the liver and reproductive organs of the chicken. To have low dust levels in the air is thus a measure to try to limit bacterial infections of the air sacs. A picture with an *E. coli* infection in the body cavity that has spread from the air sacs to the internal organs is shown in the following diagram.

[9]Oxygen is only required as long as the animal is alive, when death sets in no more O_2 is needed!

[10]Glucose can be regarded as the fuel for animal cells. In a car's engine the petrol is combusted to obtain the energy locked up in the petrol, oxygen is also required and carbon dioxide is produced. An almost similar situation in body cells except that no real fire is produced but the chemical energy locked up in the glucose comes free with accompanying heat.

Chicken with E. coli infection in the body cavity.

The blood circulation system

A simplified approach would be to view the blood system as a pipe-work of tubes, starting at the heart and branching off to enter and diffuse (getting smaller and smaller) into the tissue of organs. Inside the tissue they converge (come together again) to form veins that return the blood to the heart.

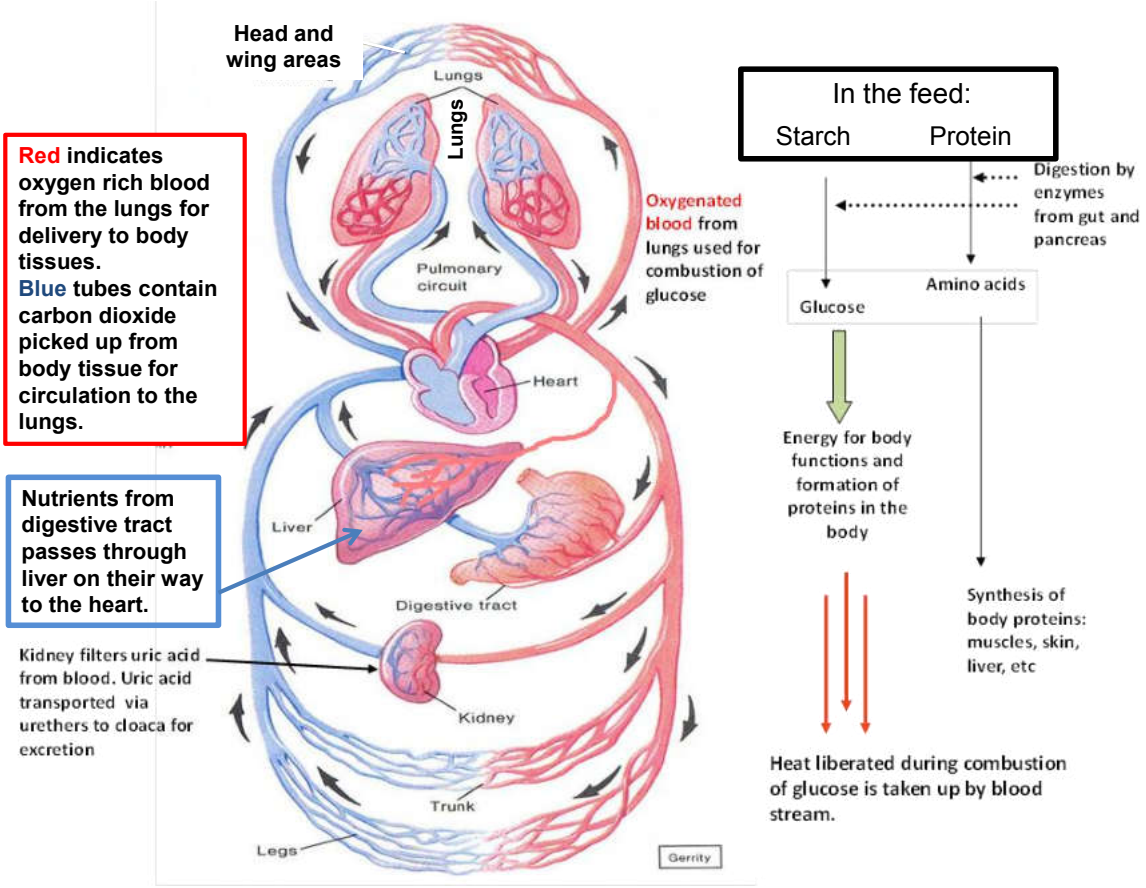


Illustration of a blood circulation system

The functions of the blood circulation system are as follows, identify these from the sketch above showing the blood circulation system and note the direction of blood flow by looking at the direction of the arrows:

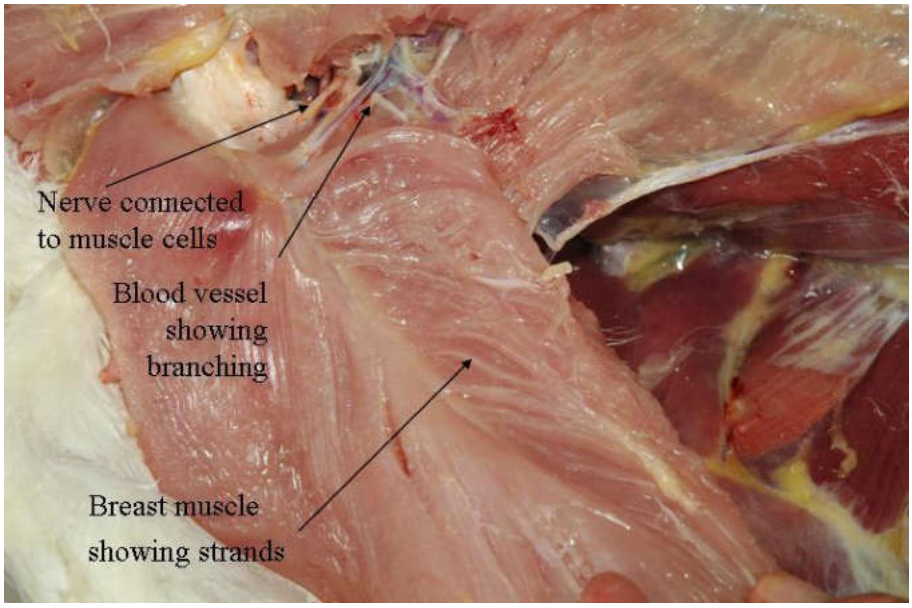
1. The heart pumps oxygen-containing blood (red blood vessels) to tissues of the various body parts where oxygen is given off and carbon dioxide picked up and blood returns to the heart.
2. The carbon dioxide-containing blood (blue vessels) is pumped to the heart and lungs. Exchange of carbon dioxide for oxygen takes place and returns to the heart.
3. Nutrients from digested feed is picked up in the digestive tract and transported to the liver and heart for distribution to body tissues.
4. Transporting heat from inner organs to the skin. This is not illustrated in the illustration above but has already been discussed in an earlier chapter ***(If you are not sure, stop and read through the notes again***). The rate of heat loss from the skin will obviously be determined by the difference in temperature of the body and the surrounding air.

The brain and nervous system

Messages are sent or received by the brain by means of a central nerve cord which branches to organs such as the eyes, ears, muscles, etc. Nerves are thus almost like a network of power lines going to the different body parts or organs and will transmit impulses to the brain. The brain then reacts depending on the type of the message.

Loud noises for example will be perceived by the brain as danger and it would send a message to leg and wing muscles to contract and to run or fly. In the case of hunger the message will be stimulated by impulses created by low levels of glucose in the blood and the bird would go to the feeder line for feed.

External factors such as lighting patterns can also act as stimulus and be picked up by the eyes. The brain can indeed be stimulated to send messages to the reproductive organs of young pullets to form egg yolk or in male chickens to form sperm cells.

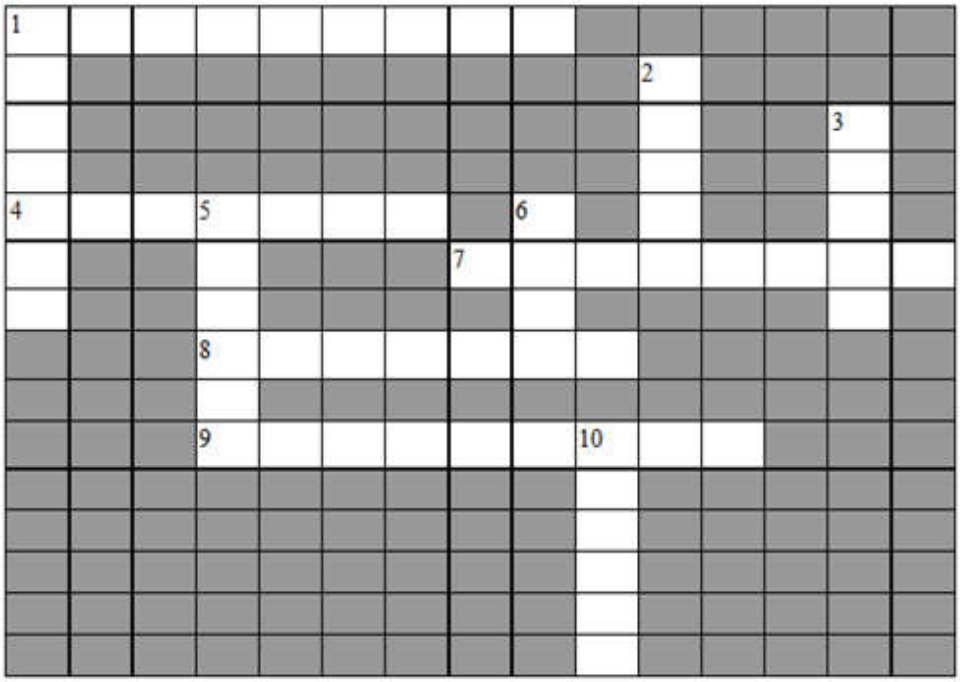


Normal nerve on the left and enlarged due to disease on the right.

Left: Nerve connected to muscle. Picture[11] on the right: Two pieces of nerve strings.

[11] Permission to use this and other pictures with the CEVA water mark was kindly granted by Prof. Ivan Dinev, Dept. of General & Clinical Pathology, Faculty of Veterinary Medicine, Trakia University, 6000 Stara Zagora, Bulgaria. E-mail: idinev@uni-sz.bg.

Test your knowledge memory challenge number 3

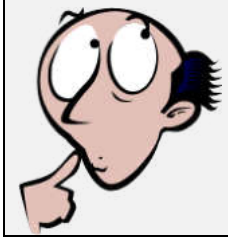


Clues Across	Clues Down	
	1	These tubes are blocked by uric acid in dehydrated chickens
	10	A network of these cords transmit messages to and from organs in the body
	2	The organ responsible for blood circulation
	3	This organ receive and send messages on signals from other organs in the body
	5	A gas that is essential for the combustion process of glucose inside body cells
	6	Air is inhaled into these body cavities that are connected to the lungs
1		Product of chemical reactions inside cells and excreted by the kidneys
4		A gas produced by bacteria in wet bedding
7		Disease causing organisms that can be inhaled into the air sacs
8		Energy for the functioning of body cells is obtained from this substance
9		The end products of feed digestion that are transported by the blood stream to body cells

Note to the learner.
Memory challenge number 3 is based on information you have learned since completing the last memory challenge. See how far you can get without referring to the notes. If you find that you are not able to complete the challenge a suggestion is to read through the notes again slowly and carefully. Should you find that you are unable to understand some of the concepts then you need to discuss these with your supervisor or facilitator.

Immune system of the chicken

The word immunity means to be protected. It therefor means that if a chicken is immune against a particular disease it is protected against that disease. The immune system is able to produce antibodies that protect the chicken against the disease for which it was vaccinated. Poultry have specific organs that are able to produce antibodies to protect them against a disease. This is the topic of our discussion and after having studied this section, you will know where antibodies are formed and what their functions are.

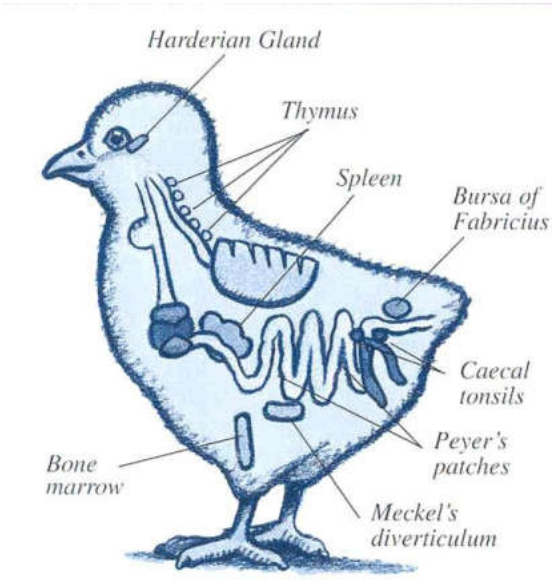
Important knowledge 	Antibodies are chemical substances consisting of proteins.
	Specific organs make antibodies (for example bursa of Fabricius, the thymus glands, the bone marrow, the spleen, etc.).
	Antibody production is stimulated by applying a vaccine to the birds.
	Antibodies attach to a disease causing organism and will render it harmless before it causes a disease.

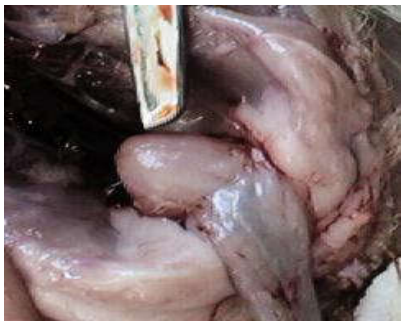
Production of antibodies.

Antibodies are proteins. You will also recall that proteins are chemical substances, occurring widely in nature and are the substances of meat, feathers, nails, liver tissue; too many to mention. Secondly, those amino acids are the building blocks of proteins. It thus means that a chicken will only be able to make antibodies if it is healthy and consuming feed.

Organs that make antibodies.

Organs involved in the production of antibodies are for example the Harderian gland, the thymus glands, the spleen, the cecal tonsils, the Bursa of Fabricius or the gland-like tissue in the gut wall, known as Peyer's patches. An organ that plays a very important role especially to protect the day-old chicken is the bursa of Fabricius





Bursa of Fabricius on the left and right indicated by the stainless steel blade.

Stimulating antibody production. (Protecting a bird against a disease).

The organs involved in antibody production can be stimulated by putting a vaccine into the blood stream. When the vaccine passes through the tissue of, for example the bursa of Fabricius, it will start making antibodies against that disease of which the vaccine was made. The amount of vaccine consumed by the chicken is most important: too little will result in low numbers of antibodies formed and the bird will be poorly protected. Too much on the other hand can make the birds sick.

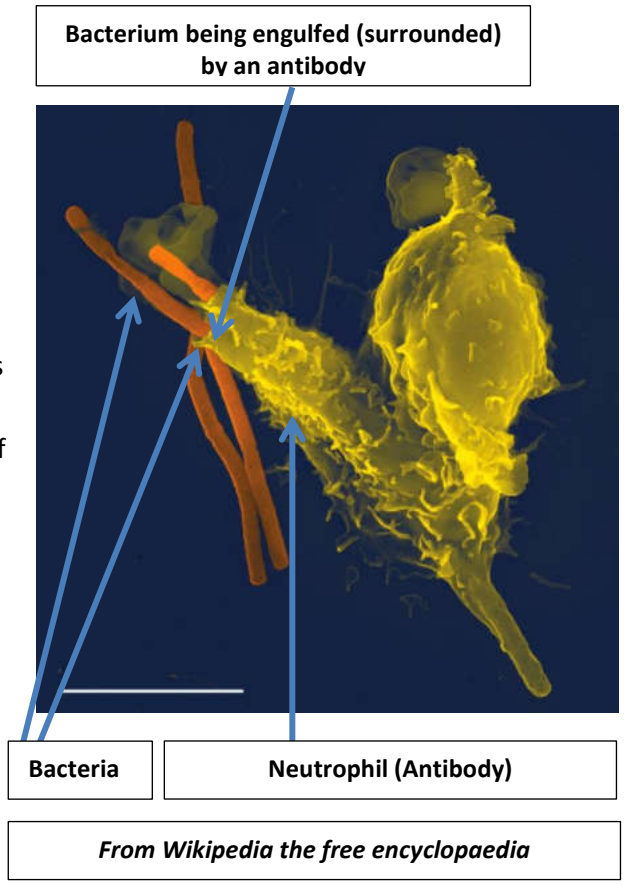
A vaccine is the weakened form of a disease causing organism, for example a virus. It does not make the bird sick if the recommended amount is given, it only causes the production of antibodies to fight the virus when it enters the bird in its original strong form.

How is the bird protected by antibodies?

Birds vaccinated against the Newcastle disease virus will have antibodies floating in their blood stream. When the Newcastle disease virus is transmitted onto a farm and penetrates the blood stream of the birds, the antibodies in the blood recognizes these viruses.

Antibodies attach to the viruses and destroy them. The degree of protection depends on the number of antibodies floating in the blood stream. The term that is used to describe this is level of immunity, the higher the number of antibodies the better is the level of protection. The picture shows an antibody binding to a bacterium to render it harmless. The antibody will not be able to destroy or bind to another bacterium and this stresses the importance of having many antibodies in the blood, in other words a high level of immunity.

The intake of the correct amount of vaccine by each and every bird is therefore most important.



Reproductive system of poultry

The Male

This material will enable you to understand the reproductive system of poultry and will include the following aspects:

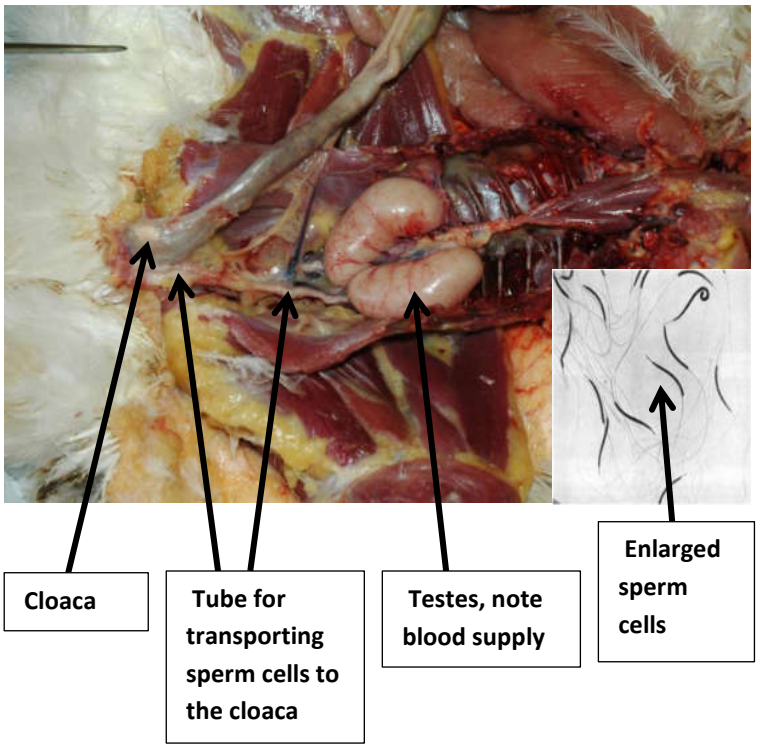
- Formation of sperm in the male.
- Growth of the female reproductive cell, the ovum.
- Fertilization of the female ovum.
- The formation of an egg.

Terminology:
Sperm – The reproductive cell of the male.
Ovum – The reproductive cell of the female, in everyday language referred to as the "yolk".
Ovary – Organ in the female containing female reproductive cells, the ova.
Oviduct – Tube in which albumen, shell membranes and shell is secreted and deposited around the ovum
Egg – Shell with contents.

The male reproductive system.

Two testes are located inside the body cavity are responsible for the formation of sperm cells.
Sperm produced by the testes flows by means of tubes to a storage chamber in the cloaca.
During mating the rooster mounts the hen and places his cloaca over that of the hen and deposits sperm onto the opening of the female reproductive tract inside her cloaca.

During mating the hen would turn the opening of the cloaca upwards, with the inside out, to receive sperm cells.
After mating the sperm is stored inside folds of the oviduct and can stay active for at least 2 weeks.



The female reproductive system (Consists of two separate organs: the ovary and the oviduct)

The ovary in the day-old hen (pullet) contains all the reproductive cells, (ova) that possibly can develop into eggs.
Each ovum is enclosed by an inner and outer membrane. The yellow yolk material, formed by the liver and transported by the blood stream, is deposited inside the inner membrane containing the genetic material of the hen. In a fully develop ovum the outer membrane will rip open, freeing the ovum, surrounded only by the thin inner membrane.

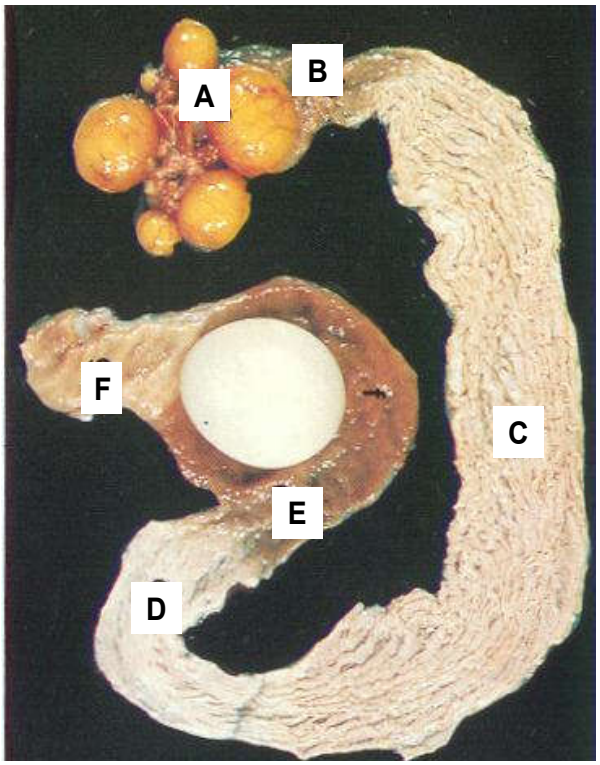
The ovum is thus what we know as the yolk. The terminology is indeed not correct as the *yolk* contains the genetic material of the hen and is thus the ovum. However, we have become so used to the terminology that it will be impossible to change. As long as we know the yolk is the ovum and the ovum is the yolk, let terminology rest in peace!

The ovary with small and mature ova

The oviduct

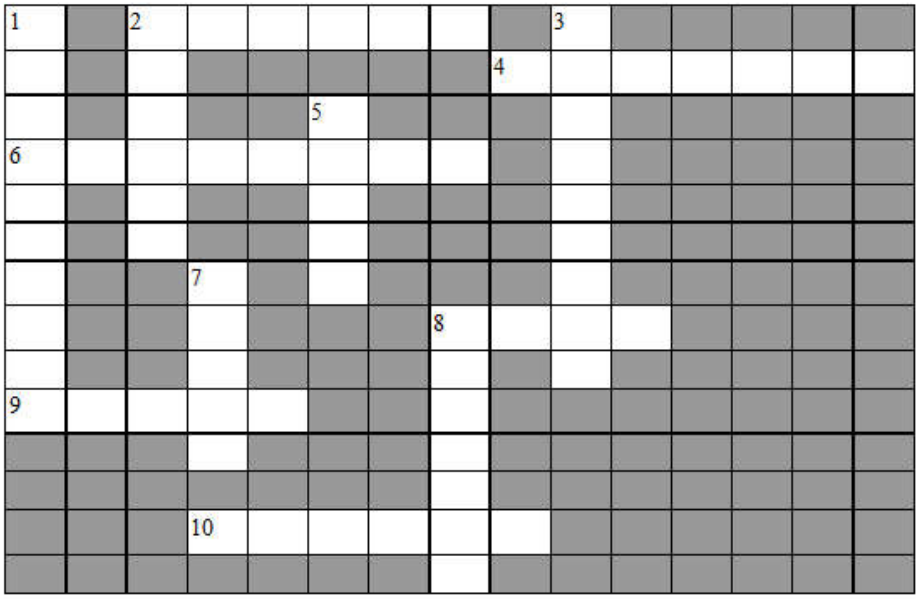
The ovarium, marked A in the picture, is surrounded with the funnel-shaped upper part of the oviduct, marked B in the picture.

The oviduct thus *catches* the ovum when it comes free from the ovarium. Sperm cells have moved up from the cloaca, marked as F, and are present in the funnel portion, marked B. Thus when the ovum enters that area, B, sperm will penetrate the membrane of the ovum and one of them will fuse with the genetic material of the hen. This is called fertilization. When an egg is placed in an incubator a chick will hatch. Other components such as egg white (albumen), is secreted in section C and the egg shell in section D.



The oviduct

Test you knowledge memory challenge number 4



Clue Across	Clue Down	
	1	These chemicals are proteins that protect the bird against a diseases
	2	These glands along the neck of the bird produce antibodies in response to a vaccine
	3	The name of a bursa that is involved in the production of antibodies
	5	A weakened form of this disease causing organism is used in the production of vaccine
	7	Organ in the female containing female reproductive cells
	8	Tube in which albumen, shell membranes and shell is secreted
2		Organs in which sperm is formed
4		Antibodies are formed in response to the application of this substance
6		This word means to be protected against a disease for which the bird was vaccinated
8		The reproductive cell of the female
9		The reproductive cell of the male
10		This organ houses a storage chamber for sperm

Note to the learner.
Your last memory challenge for this chapter, Memory challenge number 4 is based on information you have learned since completing the last memory challenge. See how far you can get without referring to the notes. If you find that you are not able to complete the challenge a suggestion is to read through the notes again slowly and carefully. Should you find that you are unable to understand some of the concepts then you need to discuss these with your supervisor or facilitator.

Solutions to the memory challenges numbers 1 to 4

Solution to memory challenge number 1			
Solution Across	**Solution Down**		
	1	Saliva	Fluid secreted by cells in the mouth of the chicken
	2	Calcium	One of the main minerals in bone cells
	3	Chemical	The type of reactions responsible for the warmth generated in the body
	5	Down	The feather-like structures with which the day-old chicken hatches
	8	Protein	One of the four components of the body that is not water, minerals or fat
4		Anatomy	Word describing the structure of the body
6		Skeleton	The framework protecting inner organs of the bird
7		Cells	The working units in tissue of organs
9		Minerals	One of the four components of the body that is not protein, water or fat
10		Glucose	This substance serves as the source of energy for a chicken
11		Amino	These acids are the building blocks of proteins

Solution to memory challenge number 2			
Solution Across	**Solution Down**		
	1	Glucose	This is the source of energy used by cells and is the result of the digestion of starch
	2	Hydrochloric	The acid secreted by the wall of the glandular stomach that assists with the digestive process
3		Salivary	Glands that secrete saliva
4		Crop	In that part of the digestive system feed is softened by water
5		Amino	Acids resulting from the digestion of proteins
6		Pancreas	The organ in the loop of the small intestine that produces enzymes for the digestion of proteins, fats and starch.
7		Fibre	This material cannot be digested by enzymes and excreted in the faeces
8		Gall	Produced by the liver to break fats up into small droplets to for enzymes to react with the fat.
9		Gizzard	The organ that grinds feed to increase surface areas on which enzymes can act to digest proteins, starch and fats in feed.
10		Colon	The last part of the gastro-intestinal tract where water that was contained in faecal matter, is absorbed.

Solution to memory challenge number 3			
Solution Across	**Solution Down**		
	1	Urinary	These tubes are blocked by uric acid in dehydrated chickens
	10	Nerves	A network of these cords transmit messages to and from organs in the body
	2	Heart	The organ responsible for blood circulation
	3	Brain	This organ receive and send messages on signals from other organs in the body
	5	Oxygen	A gas that is essential for the combustion process of glucose inside body cells
	6	Sacs	Air is inhaled into these body cavities that are connected to the lungs
1		Uric acid	Product of chemical reactions inside cells and excreted by the kidneys
4		Ammonia	A gas produced by bacteria in wet bedding
7		Bacteria	Disease causing organisms that can be inhaled into the air sacs
8		Glucose	Energy for the functioning of body cells is obtained from this substance
9		Nutrients	The end products of feed digestion that are transported by the blood stream to body cells

Solution to memory challenge number 4			
Solution Across	**Solution Down**		
	1	Antibodies	These chemicals are proteins that protect the bird against a diseases
	2	Thymus	These glands along the neck of the bird produce antibodies in response to a vaccine
	3	Fabricius	The name of a bursa that is involved in the production of antibodies
	5	Virus	A weakened form of this disease causing organism is used in the production of vaccine
	7	Ovary	Organ in the female containing female reproductive cells
	8	Oviduct	Tube in which albumen, shell membranes and shell is secreted
2		Testes	Organs in which sperm is formed
4		Vaccine	Antibodies are formed in response to the application of this substance
6		Immunity	This word means to be protected against a disease for which the bird was vaccinated
8		Ovum	The reproductive cell of the female
9		Sperm	The reproductive cell of the male
10		Cloaca	This organ houses a storage chamber for sperm